CLAIMS

Claims 1, 24, 27 and 30 are amended herein.

All pending claims are produced below. In addition, the status of each claim is also indicated below and appropriately noted as "Original", "Currently Amended", "Canceled", "New", "Withdrawn", "Original", and "Not Entered" as requested by the Office.

1. (Currently Amended) A method for robust multi-pass variable bit rate video encoding, the method comprising:

an encoding manager performing a first-pass encoding of a video sequence;

the encoding manager collecting data concerning the video sequence during the first-pass encoding;

the encoding manager utilizing collected data to construct a data analysis model concerning the video sequence, the data analysis model comprising at least a frame model concerning each frame of the video sequence, and a sequence model concerning the video sequence as a whole;

the encoding manager utilizing the data analysis model to distinguish between easy and hard segments of the video sequence to determine segment complexity of each segment and to generate a variable bit rate profile for the video sequence, the variable bit rate profile complying with a bit budget for the video sequence, avoiding buffer underflow for each frame of the video sequence, and variably allocating bits to segments as a function of segment complexity; and

the encoding manager utilizing the variable bit rate profile to perform a second-pass encoding of the video sequence.

2. (Original) The method of claim 1 wherein the encoding manager performing the first-pass encoding of the video sequence comprises the encoding manager performing a step from a group of steps consisting of:

encoding the video sequence with a constant Q, without rate control;

encoding the video sequence utilizing one pass variable bit rate encoding, thereby attempting to achieve a target bit rate; and

encoding the video sequence utilizing one pass constant bit rate encoding.

3. (Original) The method of claim 1 wherein the encoding manager collecting data concerning the video sequence during the first-pass encoding further comprises:

the encoding manager collecting data to be used to construct a data analysis model concerning the video sequence, the collected data comprising at least one data point concerning each frame of the sequence from a list of data points consisting of:

a picture type;

a bit total;

a DCT bit total;

an average mquant;

an average activity;

a scene change indicator;

a fade indicator;

a still frame indicator; and

a transition indicator.

4. (Original) The method of claim 1 wherein the encoding manager utilizing collected data to construct a data analysis model concerning the video sequence further comprises:

the encoding manager utilizing collected data to construct a frame model concerning each frame of the video sequence, the frame model comprising a formula expressing a mathematical relationship between frame bit rate, frame complexity, frame Q and frame bit overhead for each frame of the video sequence.

5. (Original) The method of claim 4 further comprising:

the encoding manager utilizing collected data to calculate complexity and bit overhead for each frame of the video sequence, and using the calculated values in the frame model.

6. (Original) The method of claim 1 wherein the encoding manager utilizing collected data to construct a data analysis model concerning the video sequence and further comprises:

the encoding manager utilizing collected data to construct a sequence model concerning the video sequence as a whole, the sequence model identifying transitions in the video sequence.

7. (Original) The method of claim 1 wherein the encoding manager utilizing the data analysis model to generate a rate profile for the video sequence further comprises:

the encoding manager calculating an initial Q for the video sequence as a function of a sum of frame complexity of the frames of the sequence, a sum of bit overhead of the frames of the sequence, and the bit budget for the video sequence.

8. (Original) The method of claim 7 further comprising:

the encoding manager calculating an initial bit rate profile for the video sequence by, for each frame of the video sequence, calculating a bit rate for that frame as a function of the calculated initial Q, the complexity of the frame and the bit overhead of the frame.

9. (Original) The method of claim 8 further comprising:

the encoding manager adjusting the calculated a bit rate for at least one frame based on at least one factor from a group of factors consisting of:

the calculated bit rate being less than a minimum number of bits for a frame;

the calculated bit rate being at least as few bits as the bit overhead for the frame; and

the frame being a transition frame in the video sequence.

10. (Original) The method of claim 8 further comprising:

the encoding manager simulating decoding of at least a portion of the video sequence according to an initial rate profile;

the encoding manager determining whether any frames underflow the buffer;

the encoding manager determining whether any frames overflow the buffer;

responsive to a segment of the video sequence transitioning the buffer from overflow to underflow, the encoding manager classifying that segment as hard;

the encoding manager calculating an updated Q for each hard segment, so as to avoid the underflow of that hard segment; and

the encoding manager calculating an updated Q for the video sequence absent any hard segments, based on the number of bits added to the bit budget as a result of calculating an updated Q for each hard segment; and

the encoding manager reformulating the initial rate profile based on the updated Qs for each hard segment and the updated Q for the video sequence absent any hard segments.

11. (Original) The method of claim 10 further comprising:

the encoding manager repeating the steps of claim 10, until a condition occurs from a group of conditions consisting of:

the encoding manager simulating decoding of the video sequence according to an initial rate profile such that the video sequence contains no hard segments; and

the encoding manager simulating decoding of the video sequence a maximum number of times; and;

the encoding manager classifying the rate profile last used to simulate decoding of the video sequence as the generated rate profile for the video sequence.

12. (Original) The method of claim 7 or claim 10 further comprising:
the encoding manager calculating a separate Q for I frames, P frames and B frames.

13. (Original) The method of claim 1 wherein the encoding manager utilizing the rate profile to perform a second-pass encoding of the video sequence further comprises:
the encoding manager encoding each frame of the video sequence according to a Q calculated for that frame by the encoding manager during rate profile generation; and
the encoding manager determining, for each frame of the video sequence, whether a bit rate for a frame encoded according to the calculated Q is within a margin of error of a bit rate calculated for that frame by the encoding manager during rate profile generation.

14. (Original) The method of claim 13 further comprising:
responsive to determining that a bit rate for the frame encoded according to the calculated Q is within a margin of error of the bit rate calculated for that frame during rate profile generation, the encoding manager accepting that encoding for that frame.

15. (Original) The method of claim 13 further comprising:

responsive to determining that a bit rate for a frame encoded according to the calculated Q is not within a margin of error of the bit rate calculated for that frame during rate profile generation, the encoding manager:

for each macroblock of that frame, constructing a macroblock model comprising a formula expressing a mathematical relationship between complexity, bit overhead, and updated bit rate, and an updated Q and for that macroblock;

encoding each macroblock according to its corresponding macroblock model; and

collecting modeling data concerning each macroblock during the encoding thereof.

16. (Original) The method of claim 15 further comprising:

for each macroblock of the frame, the encoding manager calculating an updated Q for that macroblock as a function of base Q for the macroblocks of the frame remaining to be encoded and the activity mask for that macroblock;

for each macroblock of the frame, the encoding manager calculating an updated bit rate for the macroblock, based on the updated Q, and the complexity and bit overhead of the macroblock according to the last encoding thereof; and

for each macroblock of the frame, after encoding that macroblock, the encoding manager updating, according to the encoding of that macroblock, base Q for the macroblocks of the frame remaining to be encoded.

17. (Original) The method of claim 15 further comprising:
the encoding manager repeating the steps of claim 15, until a condition occurs from a group of conditions consisting of:
the encoding manager encoding each macroblock of the frame such that a bit rate for the frame as encoded at a macroblock level is within a margin of error of the bit rate calculated for that frame by the encoding manager during rate profile generation; and
the encoding manager encoding the frame at a macroblock level a maximum number of times; and
the encoding manager accepting the last encoding of the frame at a macroblock level as the encoding for that frame.

18. (Original) The method of claim 14 or claim 17 further comprising:
the encoding manager determining whether the encoding of the frame causes underflow; and
responsive to determining that the encoding of the frame causes underflow, the encoding manager adjusting the bit rate of the frame so as to eliminate the underflow.

19. (Original) The method of claim 1 wherein the encoding manager utilizing the rate profile to perform a second-pass encoding of the video sequence further comprises:

for each frame of the video sequence, the encoding manager performing the following steps:

refining at least one model parameter concerning that frame from a group of model parameters consisting of:

bit rate; and

complexity;

updating the model for that frame based on at least one refined model parameter;

calculating an optimized Q for that frame based on the updated model; and

encoding the frame according to the optimized Q.

20. (Original) The method of claim 19 further comprising:

for each frame of the video sequence, the encoding manager ensuring that the optimized Q for that frame conforms to parameters concerning the video sequence.

21. (Original) The method of claim 19 further comprising:

for each frame of the video sequence, the encoding manager determining whether that frame as encoded according to an optimized Q results in buffer underflow.

22. (Original) The method of claim 21 further comprising:

responsive to determining that encoding a frame according to an optimized Q results in buffer underflow, the encoding manager repeating the steps of claim 19, until a condition occurs from a group of conditions consisting of:

the encoding manager determining that encoding a frame according to an optimized Q does not result in buffer underflow; and

the encoding manager encoding the frame according to an optimized Q a maximum number of times;

and;

the encoding manager accepting the last encoding of the frame as the encoding for that frame.

23. (Original) The method of claim 21 further comprising:

the encoding manager determining that encoding a frame according to its optimized Q does not result in buffer underflow; and

the encoding manager accepting the encoding of the frame according to its optimized Q as the encoding for that frame.

24. (Currently Amended) A system for robust multi-pass variable bit rate video encoding, the system comprising:

a software portion for performing a first-pass encoding of a video sequence;

a software portion for collecting data concerning the video sequence during the first-pass encoding;

a software portion for utilizing collected data to construct a data analysis model concerning the video sequence, the data analysis model comprising at least a frame model concerning each frame of the video sequence, and a sequence model concerning the video sequence as a whole;

a software portion for utilizing the data analysis model to distinguish between easy and hard segments of the video sequence to determine segment complexity of each segment and to generate a variable bit rate profile for the video sequence, the variable bit rate profile complying with a bit budget for the video sequence, avoiding buffer underflow for each frame of the video sequence~~, distinguishing between easy and hard segments of the video sequence~~, and variably allocating bits to segments as a function of segment complexity; and

a software portion for utilizing the variable bit rate profile to perform a second-pass encoding of the video sequence.

25. (Original) The system of claim 24 further comprising:

a software portion for encoding each frame of the video sequence according to a Q calculated for that frame by the encoding manager during rate profile generation; and

a software portion for determining, for each frame of the video sequence, whether a bit rate for a frame encoded according to the calculated Q is within a margin of error of a bit rate calculated for that frame by the encoding manager during rate profile generation.

26. (Original) The system of claim 24 further comprising:

a software portion for, for each frame of the video sequence:

refining at least one model parameter concerning that frame from a group of model parameters consisting of:

bit rate; and

complexity;

updating the model for that frame based on at least one refined model parameter;

calculating an optimized Q for that frame based on the updated model; and

encoding the frame according to the optimized Q.

27. (Currently Amended) A system for robust multi-pass variable bit rate video encoding, the system comprising:

means for performing a first-pass encoding of a video sequence;

means for collecting data concerning the video sequence during the first-pass encoding;

means for utilizing collected data to construct a data analysis model concerning the video sequence, the data analysis model comprising at least a frame model concerning each frame of the video sequence, and a sequence model concerning the video sequence as a whole;

means for utilizing the data analysis model to distinguish between easy and hard segments of the video sequence to determine segment complexity of each segment and to generate a variable bit rate profile for the video sequence,

the variable bit rate profile complying with a bit budget for the video sequence, avoiding buffer underflow for each frame of the video sequence, and variably allocating bits to segments as a function of segment complexity; and

means for utilizing the variable bit rate profile to perform a second-pass encoding of the video sequence.

28. (Original) The system of claim 27 further comprising:

means for encoding each frame of the video sequence according to a Q calculated for that frame by the encoding manager during rate profile generation; and

means for determining, for each frame of the video sequence, whether a bit rate for a frame encoded according to the calculated Q is within a margin of error of a bit rate calculated for that frame by the encoding manager during rate profile generation.

29. (Original) The system of claim 27 further comprising:

means for, for each frame of the video sequence:

refining at least one model parameter concerning that frame from a group of model parameters consisting of:

bit rate; and

complexity;

updating the model for that frame based on at least one refined model parameter;

calculating an optimized Q for that frame based on the updated model; and

encoding the frame according to the optimized Q.

30. (Currently Amended) A computer readable medium containing a computer program product for robust multi-pass variable bit rate video encoding, the computer program product comprising:

program code for performing a first-pass encoding of a video sequence;

program code for collecting data concerning the video sequence during the first-pass encoding;

program code for utilizing collected data to construct a data analysis model concerning the video sequence, the data analysis model comprising at least a frame model concerning each frame of the video sequence, and a sequence model concerning the video sequence as a whole;

program code for utilizing the data analysis model to distinguish between easy and hard segments of the video sequence to determine segment complexity of each segment and to generate a variable bit rate profile for the video sequence, the variable bit rate profile complying with a bit budget for the video sequence, avoiding buffer underflow for each frame of the video sequence~~, distinguishing between easy and hard segments of the video sequence~~, and variably allocating bits to segments as a function of segment complexity; and

program code for utilizing the variable bit rate profile to perform a second-pass encoding of the video sequence.

31. (Original) The computer program product of claim 30 further comprising:

program code for encoding each frame of the video sequence according to a Q calculated for that frame by the encoding manager during rate profile generation; and

program code for determining, for each frame of the video sequence, whether a bit rate for a frame encoded according to the calculated Q is within a margin of error of a bit rate calculated for that frame by the encoding manager during rate profile generation.

32. (Original) The computer program product of claim 30 further comprising:

program code for, for each frame of the video sequence:

refining at least one model parameter concerning that frame from a group of model parameters consisting of:

bit rate; and

complexity;

updating the model for that frame based on at least one refined model parameter;

calculating an optimized Q for that frame based on the updated model; and

encoding the frame according to the optimized Q.